Solar Pumping System for Rural Areas Water Supply in Nigeria

Muhammadu Masin Muhammadu
Department of Mechanical Engineering, Federal University of Technology, P.M.B. 65, Gidan-Kwanu, Minna, Nigeria.
Masin.muhammadu@futminna.edu.ng
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Abstract

Nigeria is endowed with abundant energy resources, both conventional and renewable, which can potentially provide the country with a sufficient capacity to meet the ambitions of both urban and rural Nigerians of a full, nationwide electrification level. Yet, Nigeria has one of the lowest consumption rates of electricity per capita in Africa. With the demand superseding the generation, there is inequitable access of rural communities to the electricity service in the country. There are inherent obstacles militating against the effective implementation of an orderly energy policy in Nigeria. The inefficiencies over shadowing the allocation of energy resources coupled with the near depletion of fossil fuels, make it imperative for the country to exploit its huge natural renewable resources to avoid a worsening energy supply scenario and provide feasible solar water pump to rural dwellers. This paper presents the applications of solar water pumping which are already quite significant and are growing at steady rate. Solar energy is suitable for small-scale water pumping in remote areas where the demand is regular, such as for drinking water, but it may also be used for irrigation. Most areas in Nigeria have climates suitable for solar pumping. A review is given of the use of solar energy for water pumping to improve the living conditions of the population in rural areas and to develop techniques for utilization of solar energy in a tropical environment condition. Results, suggests that, solar powered water pumping must be encouraged, promoted, invested, implemented, and demonstrated by full scale in Nigeria.

Introduction

The two of most essential natural resources for all life on the earth and for man's survival are sunlight and water. Water is more precious than the rarest of diamonds. In many parts of the world today, however, environmental conditions such as topography and weather have caused drought resulting in a scarcity of water supply. This fact, coupled with the shortage of both underground and surface water supplies, has now made it mandatory to develop new systems for providing fresh and clean water [1].

The sources of energy commonly used for rural water pumping are human or animal power, electricity and oil. Although diesel and electric pumps may be attractive, difficulties in securing regular energy supplies and the facilities required for maintenance may limit their application. For this reason interest in the use of renewable sources of energy for small water pumping systems in remote homes and communities is growing. In areas of the world where sunlight is a natural resource in abundance, a reasonable scheme is to use solar energy to help provide the scarce resource, water. Photovoltaic (PV) devices (solar cells) are being used to power water pumps for potable water supplies in world. However, the volume of water pumped by solar energy is still only a small fraction of the total, even though the cost of some systems in no higher than their fuel-powered equivalents. Unfamiliarity with the technology, even though it is easy to understand, is perhaps a significant barrier to the wider use of solar pumps today. Over the past 30 years approx. 350 PV water pumps have been installed in Nigeria. Considerable progress has been made and the present generation of systems appear to be reliable and cost–effective under certain conditions. A PV pumping systems to pump 500 m^3 per day through 25 mm head requires a solar array of approx. 800 Wp. such a pump would cost US$250, since the total system comprises the cost of modules, pump, motor, pipework, wiring, control system and array support structure. PV water pumping has been promoted successfully in Northern part of Nigeria.

Despite the abundance of energy resources available, Nigeria is only able to generate 1600 MW effectively out of 6000 MW of installed generating capacity (less than 30%). This is because most of the power grid facilities are poorly maintained. Nigeria's power sector retains high energy losses, between 30% and 35%, from generation to billing. This is significantly high as compared with the US, where power losses across lines usually come to less than 7%, even across long distances [5]. In addition, there is a low collection rate,75 to 80%, and low access to electricity by the population. Declining electricity generation from a number of domestic power plants has sent the country into an energy crisis during 2002/2003. Currently, the actual electricity generation of the country is considerably below the demand for electrical energy as shown in Figures 1 and 2.

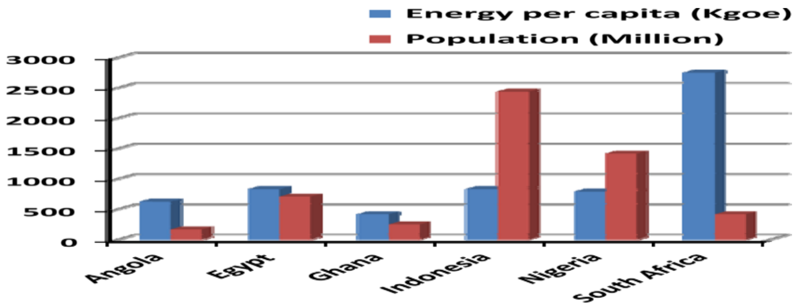

Fig.1: Energy per capital of some selected countries [5].

At present, only 10% of rural households and 40% of the country's total population have access to electricity

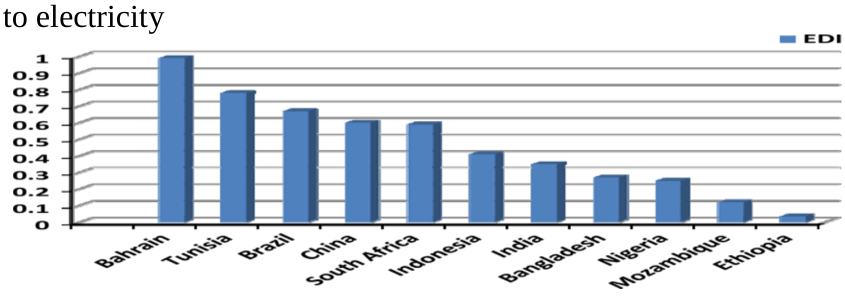

Fig.2: Energy development index ranking of some selected countries in the world [5].

Potential for Solar Energy in Nigeria

Sunlight is the driving force behind many of the renewable energy technologies. The world-wide potential for utilizing this resource, both directly by means of the solar technologies and indirectly by means of biofuels, wind and hydro technologies is vast. The sun is a sphere of intensely hot gaseous matter with a diameter of 1.39×106 km and, is on average, a distance of 1.5×1018 km from earth [4]. Energy occurring in the sun comes from the thermonuclear reaction; the reaction causes the reduction in solar mass by approx. 4×109 kg /s, and simultaneously releases energy at rate of 3.85×1023 kW. However, only 1.79×10^4 kW of solar energy is received by the earth. Solar energy is an inexhaustible source of energy. The solar constant is defined as the amount of energy which received at the outer fringe of the earth's atmosphere 1.35 kW m^{-2} [2]. The solar radiation before reaches the earth surface affected by many factors, i.e. absorption, scattering, and reflection.

Field Experience/System Design and Economics

The cost of a PV pumping system is high and roughly proportional to the size of the system, especially the PV array, so, the system should be the smallest to provide the amount of water needed. The average daily solar irradiation in the least sunny month may be used together with the lift and the maximum daily water requirement to determine the PV array size. The other components that must be selected are the motor, the pump and the pipe diameter. If the benefits of the solar pump designed exceed the costs of the installation and operation, and if these costs are less than those of other pumping systems, then the solar system will be judged to be economically feasible. Such economic evaluation may, however, be distorted by external factors, e.g. if taxes are light on diesel fuel but heavy on PV modules, then solar pumping will suffer an artificial disadvantage versus diesel pumping. On the other hand donated or subsidized solar pumps may give the false impression that the pumps are economically feasible when in fact they are not.

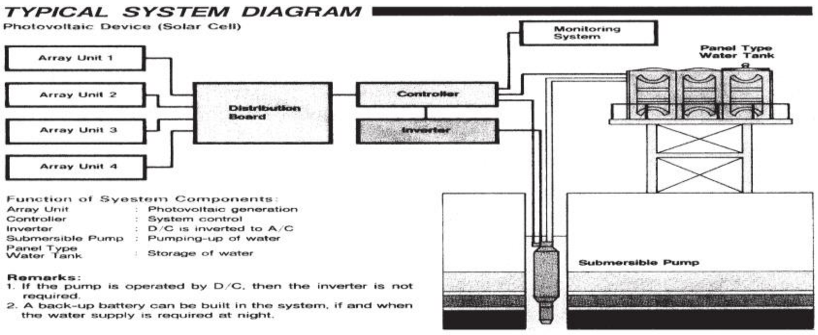

Fig.4: Solar water pumping system at Bosso, Nigeria (Muhammadu M.M., 2012).

Energy is an indispensable ingredient for the socio-economic development and rapid urbanization. Modern economic activities depend predominantly on petroleum products and electricity. However, there is serious economic and demand capacity constraints in the extension of the latter sources from urban to the rural areas. Rural dwellers are famished, their energy demand levels are low and the center of demand is scattered. Only 18% of rural dwellers are exposed to electricity while almost 81% of the urban dwellers have access to it. In addition, while kerosene can be purchased in some urban centers at pump price, its retail price in rural areas is often higher [3].

Easy data loggers have been installed in Nigeria since 2009 to collect values of module temperatures, solar radiation intensity, flow rate, array voltage and current. The overall goals for technical monitoring were:

- To characterize the day to day performance of solar pump as a function of energy resource level,
- To determine pumping rates as a function of power input; and
- To monitor the maintenance and repair requirements, for which little data exists in Nigeria.

Solar radiation ranged from 5.5 to 7.5 kW m $^{-2}$ /day in the plane of the solar array. The peak pumping rate was 82l min^{-1} at 820 W/m^{-2}. Field experience from PV installation in Nigeria showed that operation and maintenance cost is negligible. However, average overall system efficiency is still low. At present the system is not yet competitive with a conventional pump set but in the near future, as the costs fall and efficiencies rise, it is foreseen that the PV water pumping system is economically suitable for applications in rural areas.

Social Aspects of Solar Pumping and Lack of Portable in Rural Areas.

The social and institutional matrix within which solar pumping occurs may be more important than technological factors for the success of a project, rural dwellers must be involved in the planning of the system and the building of the local infrastructure, although professional support must generally be brought in from outside. A local management committee is needed to decide how to distribute the water equally, to handle the finances, and to carry out routine maintenance. Some unexpected problems occurred, including unauthorized cutting of the pipes. Although the original purpose was to provide clean drinking water, the water was eventually used more for domestic because the villagers preferred the taste of water from well.

Types of Solar Pump

- Submerged multistage centrifugal motor pump sets**:** they are probably the most common type of solar pump for village water supply. The advantages of this type it is easy to install and the motor pump set is submerged away from potential damage. The most commonly employed system consists of an A,C. pump and inverter with PV array of loss than 1500W, but D.C. motors are also used.
- Reciprocating positive displacement pumps: They are very suitable for high-head, low-flow applications, they are often more efficient than centrifugal pumps.
- Floating motor-pump sets**:** they have a versatility that makes then ideal for irrigation pumping from canals and open wells. The pump set is portable and there is a negligible chance of pump running dry. The solar array support often incorporates a “wheel barrow’ type trolley to enable easy transportation [2].

Conclusions

A significant proportion of the Nigerian population is living in rural communities, located quite far off the nearest connection to the National grid. These rural communities have no proven deposits of natural gas, crude oil or large rivers, but are, however, blessed with abundant renewable energy (RE) resources. Apart from large hydro and conventional biomass, RE resources in Nigeria are presently not given any consideration in the country's energy supply mix and are even marginalized in future energy plans. Notwithstanding the fact that, Nigeria is generally blessed with ample conventional and renewable energy resources, the demand is significantly higher than the energy generated. Because of the abstruse in efficiencies associated with electric energy provision in Nigeria, it is increasingly harder for rural Nigerians to have access to the electricity service. Energy is critical in both how it impacts the global environment and how it is needed to protect the local environment. Access to clean energy is an essential component of sustainable development. Tapping of solar energy for rural development is, therefore, expected to emerge as an important renewable source of energy in Nigeria. There are many other factors which support this outlook. Among them are the remoteness of rural areas, scarcity of water, abundant sunshine and simplicity of the routine maintenance of solar devices

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